



# **The Rare Isotope Accelerator (RIA) Research & Development Workshop**

**DOE Nuclear Physics Division**  
**August 26-28, 2003 • Bethesda, Maryland**

## **CHARACTERIZATION OF SECONDARY RADIATION FROM PRE-CONCEPTUAL HIGH POWER TARGETS**

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# Why Important!

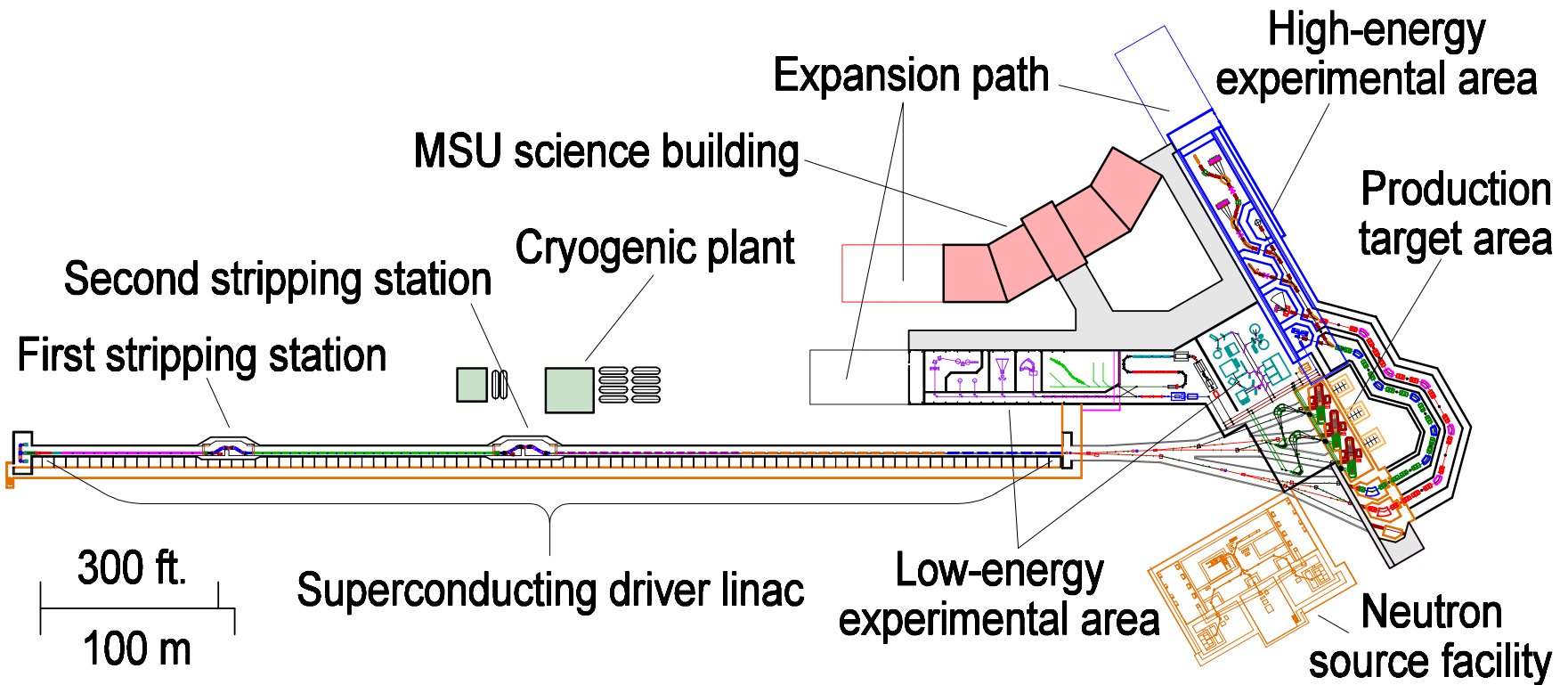
- ◆ **Characterization of Secondary Radiation is a High R&D Priority:**
  - ◆ **Support Facility Characterization**
  - ◆ **Bulk Shielding Design**
  - ◆ **Range of R&D activities**
    - ◆ ISOL targets
    - ◆ Fragmentation targets
    - ◆ Radiation-hard magnets

# Characterization of Secondary Radiation

## – *Recommend as High Priority!*

- Power is ~10 to ~100 higher than delivered to existing similar targets
- Power dissipation will lead to significant:
  - Prompt Secondary Radiation
  - Radioisotope Inventory
  - Activation
  - Heating ...
- Necessary to characterize in support of:
  - Civil engineering
  - Bulk shielding (biological doses ...)
  - Environmental impacts
  - Facility classification
  - R&D of Target areas, Stripper regions
  - Magnet designs
  - Materials (dose, activation, maintenance *etc.*)
  - Remote handling

# MSU's Current RIA Layout



# LINAC Stripping Regions

- **Controlled Losses: 2 Stripping targets required for  $A > \text{Xe}$**
- **For 400 kW beam power:**
  - **1<sup>st</sup> stripper power density about 3 kW/mm<sup>3</sup>**
    - **$\sim 10 \text{ A MeV}$**
  - **2<sup>nd</sup> stripper power density about 2 kW/mm<sup>3</sup>**
    - **$\sim 100 \text{ A MeV}$**
- **Stripper design must be supported**
- **Remote handling, local shielding must be investigated**

# Nuclear Safety and Hazard Analysis

- Need to Answer Early-On:

## Is RIA a Nuclear Facility or Accelerator Facility?

- Areas to study:
  - *Hazardous material inventory*
  - *Potential for release*
  - *Other attendant hazards*
- If a Nuclear Facility, What Category?
  - ISOL Targets are most likely the decision driver
    - need realistic designs to study and help promote target area R&D

# Preliminary Conclusions on Classification

- **Several groups working on this issue:**
  - **MSU**
  - **LLNL (Larry Ahle and Jason Boles, this Workshop)**
  - **ANL**
- **Storage area, target, hot cell, pre-separator areas: Cat. 2**
- **The rest of the facility: Cat. 3**

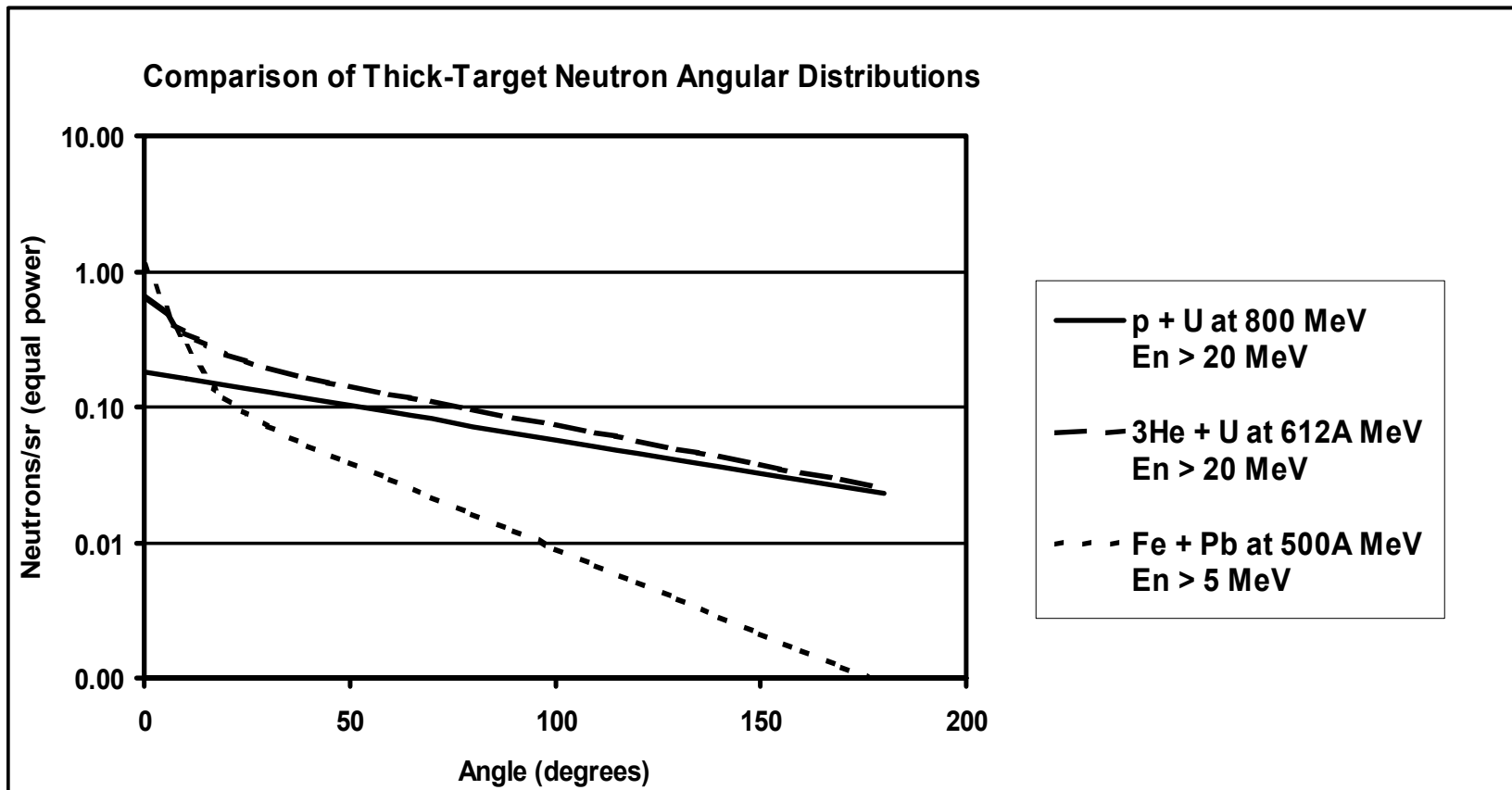
# Characterizing Secondary Radiation

- **Clear Need to use Transport Codes to Simulate the Radiation Environments in Target Areas and Around Beam Dumps for Both Light and Heavy Ions**
- **Light Ions ( $A < 5$ )**
  - **Monte Carlo transport codes available**
  - **Other developed tools for simulations available**
    - *e.g.* ORNL's Activation Analysis Sequence codes
- **Heavy Ions**
  - **Transport codes still under development and not generally available**
  - **Benchmarking will be necessary**

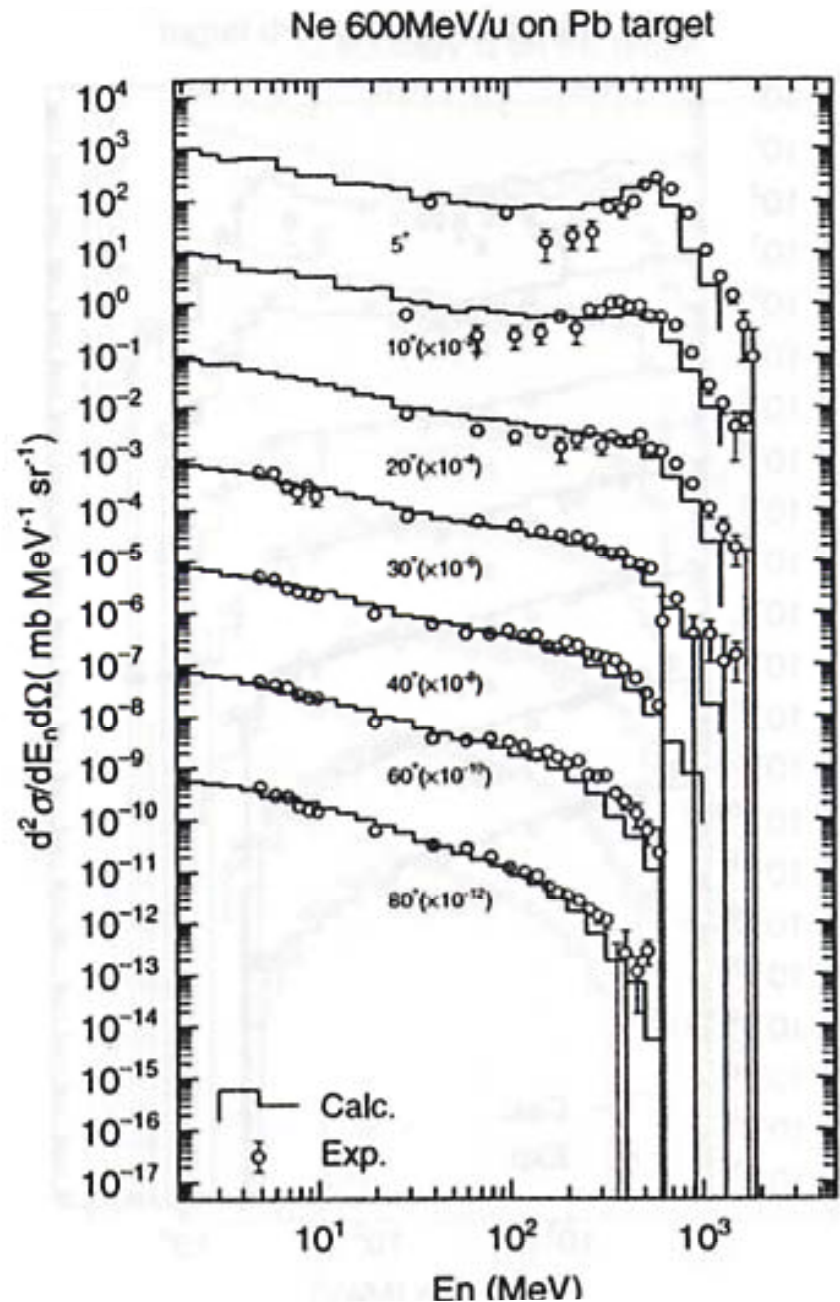


# Angular Distributions of Neutrons

- Characterization of radiation will be important for R&D
  - Character of neutron spectra different
  - Critical data does not exist



- **PHITS calculation:**  
Hiroshi Iwase  
Ph.D. thesis  
Tohoku Univ. (2003)
- **Data**  
Y. Iwata et al.  
Phys. Rev. C 64,  
054609(2001)

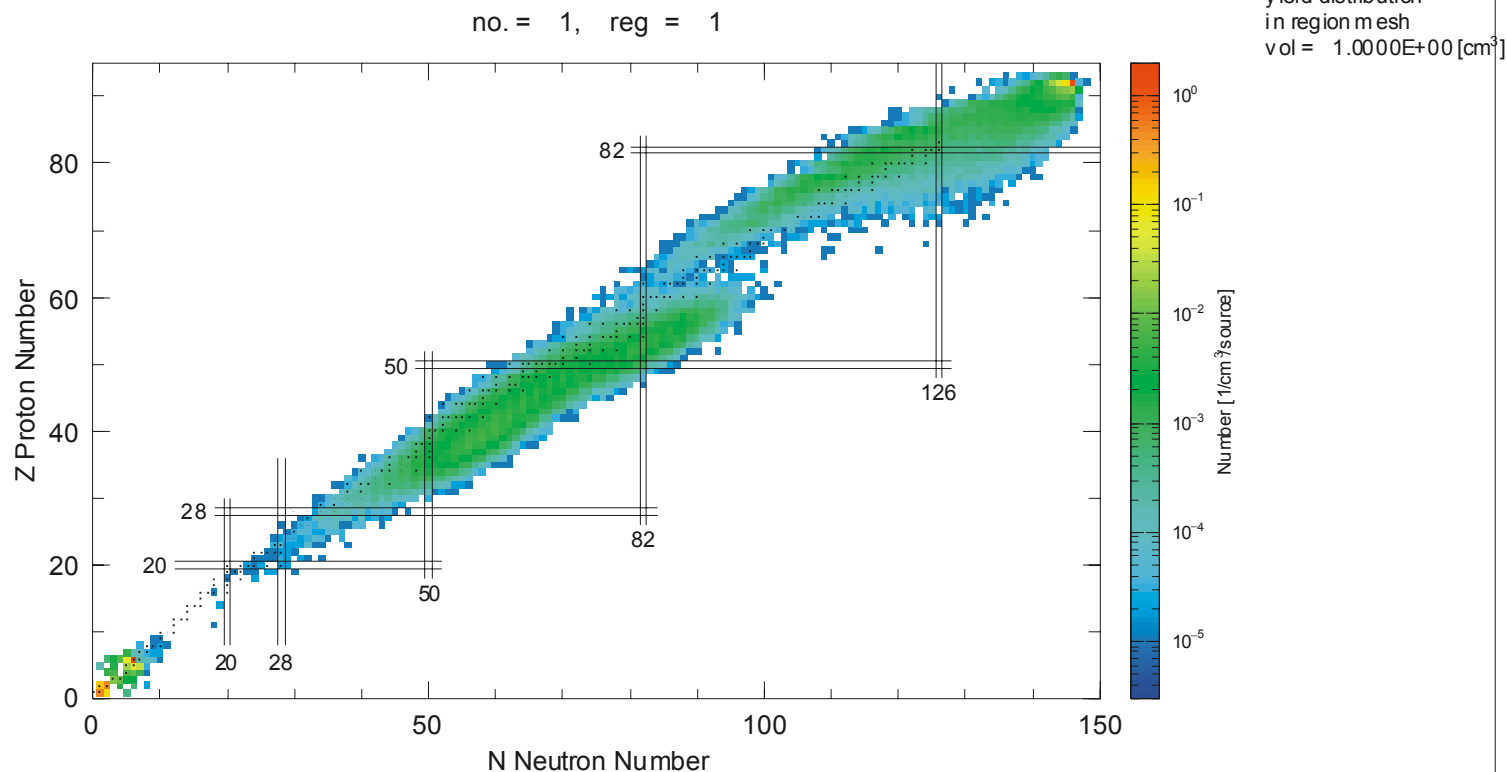


# PHITS: $^3\text{He}$ at 730A MeV on UC Target+Cu Stop

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huge [t-yield] in region mesh

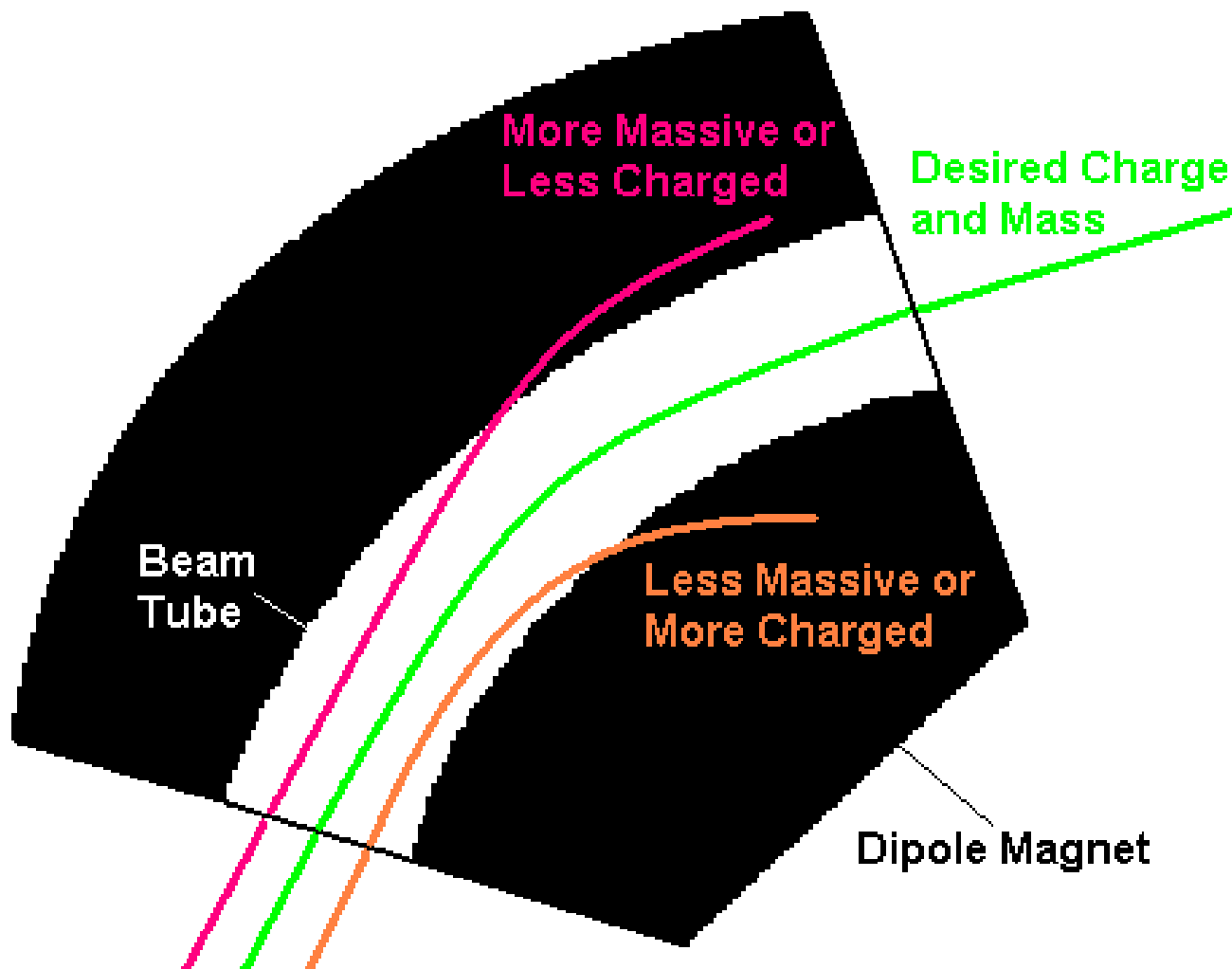
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# Fast Fragmentation Target Area Issues

- **For 400 kW target: 50 - 100 kW from fragments!**
  - **Where will these fragments go?**
  - **Where will the primary beam go?**
  - **What magnet designs will work?**
- **Significant R&D effort is necessary to simulate radiation environment of target area**
- **Simulations will need heavy ion transport codes**

# Complexity After the Fragmentation Target!



# Radiation Damage

## Radiation Damage by Fast Neutrons Not Well Studied!

- ◆ Most data are for:
  - ◆ neutrons having energies thermal to ~14 MeV
  - ◆ photons
- ◆ Simple dose estimates (neglecting HE cascade neutrons) give:
  - ◆ < 8 year SC coil life
    - ◆ Preliminary Monte Carlo analysis gives 4 years
  - ◆ **Unacceptably Short Coil Lifetimes!**

# Support Radiation-Hardened Magnet R&D

- ◆ **Need to understand radiation environment in ISOL, fragmentation target and other magnetic device areas:**
  - ◆ **Will drive magnet design**
  - ◆ **Need data, code development and benchmarking for DPA analysis of damage to magnet components**
  - ◆ **Residual radiation determines servicing scenarios**

# Summary and Conclusions

- **Support for radiation characterization is vital!**
  - **Facility classification:**
    - Inventories of radioisotopes and attending hazards must be studied carefully and early-on.
  - **Support RIA R&D:**
    - Yields and angular distributions of secondary neutrons and other radiation from heavy ion reactions must be known from data or simulations.
    - New codes necessary for simulations.
      - Benchmarking will be necessary.
      - Need to have the necessary data sets.



# BACKUP SLIDES

# PHITS: $^3\text{He}$ at 730A MeV on UC Target+Cu Stop

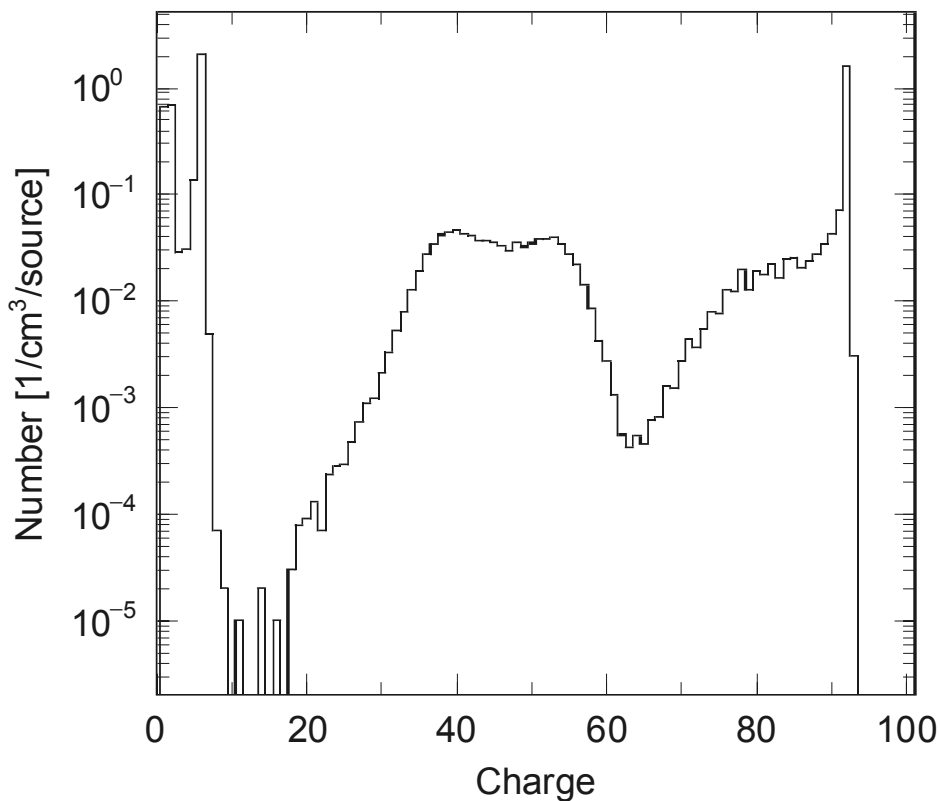
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no. = 1, reg = 1

charge distribution  
in region mesh  
vol = 1.0000E+00 [cm<sup>3</sup>]



plotted by eargeA\TINY\tiny\TINY\tinyCharge\TINYL 4.22

calculated by eargeP\TINY\tinyHIT\TINY\tinyS 1.35

# PHITS: $^3\text{He}$ at 730A MeV on UC Target+Cu Stop

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mass distribution  
in region mesh

reg = 1

vol = 1.0000E+00 [cm<sup>3</sup>]

Z = all

